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INFINIUM TECHNOLOGIES LIMITED,
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[ADP No. 08598922001]

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2.	**Patent application number** *(The Patent Office will fill in this part)*	0208048.9 — 8 APR 2002
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	Digicliff Ltd. Evershed Court Telscombe Cliffs East Sussex BN10 7BU SECTION 32 (1977 ACT) APPLICATION FILED 26/03/03
	Patents ADP number *(if you know it)*	8359747001
	If the applicant is a corporate body, give country/state of incorporation	United Kingdom
4.	**Title of the invention**	Optical Controls
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Optical Controls

The present invention relates to optical controls, such as optical switches and optical encoders. More particularly, the invention relates to optical controls, such as toggle switches and selector switches, which provide an output indicative of the state of the switch. The invention also relates to optical controls, such as turn knob controls, slider controls and so forth, which comprise optical encoders that provide an output indicative of the position of a control member. The invention extends to optical encoders *per se* that can provide an output which indicates the position, or movement, of a mechanical element.

Many conventional mechanical controls convert a mechanical input, such as the flicking of a switch or the positioning of a turn knob or slider, into an electrical output. For example, a conventional turn knob control may comprise a rotary potentiometer in which the position of a movable electrical contact generates an analogue signal indicative of the position of the turn knob. Similarly, a conventional slider control may comprise a linear potentiometer.

There has however been a trend away from the use of such conventional controls, and towards the use of non-contact optical controls. This has occurred for a number of reasons.

One factor in the increased use of optical controls is that conventional controls, such as potentiometers, rely on the mechanical movement of one part against another which can lead to mechanical wear. Such controls may therefore have a shorter operating life when compared to an equivalent, non-contact optical control. A further problem associated with many conventional controls is corrosion of metal parts, such as electrical

contacts, which can again reduce the useable lifespan of this type of control. Mechanical switches can also be susceptible to switch contact bounce which can require a time delay to be built into the switch operation to avoid, e.g., multiple switching due to such "bouncing".

Optical controls may also be preferred due to the increasing desire to use digital rather than analogue technology in electronic equipment. Unlike some conventional mechanical/electrical controls, such as rotary and linear potentiometers, which provide an analogue output and so require additional electronics to convert the analogue output from the control into a digital signal, optical controls can more easily directly provide a digital output that can be directly interfaced with, e.g., a microprocessor, and so can avoid the additional expense of providing electronics to convert an analogue signal.

One example of a simple optical control is an on/off switch which comprises a light source, a light detector and means, such as a toggle lever, that can be moved to selectively block light from passing from the light source to the light detector. The light source may comprise, say, a light emitting diode and the light detector may comprise a phototransistor. The electrical output of the phototransistor indicates the state of the switch.

Optical equivalents of conventional rotary turn knob controls and linear slider controls are also known. In these types of optical controls, unlike in simple switches, a control member has a range of movement, and the position of the control member within this range is determined by optical means. Devices of this type are usually called optical encoders since they generate a digital code characteristic of, and dependent on, the position of the control member.

A simple form of a rotary optical encoder comprises a rotatable shaft, one end of which is attached to a

control member that can be turned by a user. The other end of the shaft is located within a housing and is attached to, and moves with, a radially extending disk. The disk is formed from a photographic material and is divided into a number of concentric tracks. Each track comprises a pattern of transparent and opaque regions which, respectively, allow or prevent light from passing through the disk. A number of light sources are positioned on one side of the disk, one light source in line with each track on the disk. On the other side of the disk, a number of light detectors are positioned, again one light detector in line with each track on the disk. In this way, light from a light source can be directed through each track at a corresponding light detector. Each light detector indicates whether or not it is exposed to light, i.e. whether it is covered by a transparent or opaque region of its respective track. Thus if four tracks and four light detectors are provided, the pattern of transparent and opaque regions on the tracks can be arranged to generate 16 unique digital codes (typically in a Gray code form) which correspond to 16 angular sub-ranges of the total range of angular movement of the control member. Typically, in practice, a greater number of tracks would be provided to achieve a greater angular resolution, say 8 tracks providing 256 codes representing 256 distinct angular sub-ranges of the total movement of the control member.

A typical linear optical encoder employs the same principle but instead of providing a code generating disk, a linearly movable plate is provided connected to a linear slider. The plate includes a number of linear patterned tracks and is disposed between a number of light sources on one side and a number of light detectors on the other side.

Whilst known optical controls and encoders of the type described above have a number of advantages,

particularly over more conventional mechanical controls, they also suffer from a number of drawbacks.

For example, a typical conventional optical control has the light sources and corresponding light detectors arranged in a face-to-face relationship, and typically comprises a first subassembly comprising one or more light sources, typically LEDs, mounted on a printed circuit board, and a second subassembly comprising one or more light detectors, typically phototransistors, mounted on a second printed circuit board. The printed circuit boards provide support to and electrically connect the various electronic components. The two subassemblies are then mounted within a housing facing each other, which housing also includes electrical connectors to enable the control to be mounted and connected to other components, such as a main printed circuit board. The construction of such controls, and the mounting of these devices on a main printed circuit board as is often required, can be relatively labour intensive and time consuming.

The present invention therefore aims to improve on known optical controls, such as optical encoders, and in particular, aims to provide improved forms of construction of such components.

From a first aspect, the present invention provides an optical control comprising:

one or more light sources; and

one or more reflectors arranged to reflect light from the light source or sources to redirect that light.

In the optical control of this aspect of the present invention a reflector is used to redirect light from the light source. Using a reflector in this manner enables increased flexibility in the positioning and orientation of the optical components within the optical control, as it, for example, removes the restriction in conventional optical controls of having to arrange light sources and light detectors in a face-to-face

relationship.

A simple form of the invention may, for example, comprise an optical control provided with a single light source and a single light detector, wherein light from the light source is reflected by a reflector onto the light detector. The invention however is not limited in the number of light sources, light detectors and reflectors that may be provided in an optical control, provided that some form of reflector is used to direct light.

The type of light source used in the present invention may comprise any suitable light emitting device. Preferably, the light source comprises an electronic component, such as a light emitting diode (LED), which produces light from an electrical input. Most preferably, the light source comprises an infra-red LED.

The light from the light source or sources should be redirected via the reflector to a light detector or detectors for appropriate detection (with the presence or otherwise of light at the detector(s) being indicative of the state of the optical control, as is known in the art). The light detectors themselves could be mounted, as is conventional, in close proximity to the light sources, i.e. be part of the optical control itself, with those light detectors then providing an electronic signal which can be transmitted elsewhere for processing, etc. Thus in one preferred embodiment, the optical control further includes one or more light detectors.

However, it is not necessary with the arrangement of the present invention to mount the light detectors for the optical control in relatively close proximity to the light sources. Indeed, the Applicants have recognised that there may be some circumstances where it may be advantageous not to have to mount the light detectors close to the light sources of a given optical

control. For example, where there are plural optical controls on, e.g., a single circuit board, it may be advantageous to be able to use the same light detectors for each control (e.g. in terms of component numbers and ease of construction). The present invention facilitates such a construction since it, for example, allows the optical output of a control to be directed as desired by the reflector (e.g. via an optical fibre to an "off-control" light detector).

Thus in another preferred embodiment of the invention, the arrangement and preferably the optical control includes light transmitting means that can transmit the optical output of the control to a light detector or detector(s) that is or are spaced apart from the optical control (e.g. mounted elsewhere on the printed circuit board). In this arrangement, preferably one set of light detectors, e.g. provided integrally with a main microprocessor of the system, receives the light output from plural optical controls. In this way an optical rather than electrical connection may be provided between the optical controls and other components, such as a microcontroller of the system.

This arrangement is believed to be advantageous in its own right and thus from a further aspect, the present invention provides an optical control, wherein the control provides an optical output indicative of the state or position of the control, and wherein the optical output can transmitted by light transmitting means to another remote component for subsequent processing.

From a yet further aspect, the present invention provides an optical system comprising a number of optical controls, wherein the optical controls each provide an optical output indicative of the state of the control; the system further comprising light transmitting means to transmit the optical outputs of the controls to a processing unit capable of reading the

optical data generated by the controls.

In these arrangements, the light transmitting means may take any suitable form, such as an arrangement of optical fibres. The light transmitting means can preferably be relatively easily fixed in position, say to the underside of a printed circuit board. In this way, a number of light transmitting means can be provided to effectively form a data bus which conducts light as opposed to electrical current which would be carried by a conventional electronic data bus.

The light transmitting means should provide the optical information in the output from the optical control to remote light detectors where the optical output is converted into electrical data so that it can be processed, say by a microcontroller. Preferably therefore an arrangement of light detectors, such as phototransistors, is provided to receive the optical information from the light transmitting means. The means of converting the optical data into electronic data may take any suitable form and may, for example, be provided integrally with a main processing unit or alternatively as a separate unit.

Thus, in one preferred arrangement of the present invention, an optical system comprises a number of optical controls that do not themselves include light detecting means, but instead transmit their optical data via, say optical fibres, to a set of light detectors which finally convert the optical data into electronic data. In this way, particularly on larger control panels which have many optical controls, significant cost savings can be made since the number of light detectors required can be reduced.

The light detectors themselves may take any suitable form. Preferably, they comprise an electronic component, such as a phototransistor, which produces an electric current when exposed to light.

The reflector or reflectors may take any suitable

form for redirecting the light from the light sources. A reflector may comprise a separately formed element or alternatively may be integrally formed with a housing for the control. Preferably, the reflector comprises a moulded element, say formed from plastic, that is provided with a reflective, mirrored coating. A single or more than one reflector may be provided.

In a particularly preferred embodiment, the reflector or reflectors are arranged to reflect light from a single light source to plural light detectors (via light transmitting means, if desired). For example, the light from one light source could be appropriately redirected by a reflector to two (or more) different light detectors. This would allow a number of light detectors to be operated using light from one light source. This arrangement allows optical controls to be constructed using fewer components, thus providing more simplified construction and cost savings.

Indeed, it is believed that this arrangement may be advantageous in its own right. Thus, from a further aspect, the present invention provides an optical control comprising:

one or more light sources;

means for splitting the light from a single light source into plural different paths, whereby light from one light source can be directed at plural different light detectors.

From a further aspect, the present invention provides an optical control comprising:

one or more light sources;

a plurality of light detectors;

wherein light from one light source is directed at two or more of the light detectors.

In these aspects of the invention, light from the light source can be directed at a number of light detectors by any suitable means, such as by the use of known optical components such as mirrors, prisms,

optical fibres and so on. It is preferably, as discussed above, directed at a number of light detectors using one or more reflectors.

The way that the reflector or reflectors, etc., directs light from one light source to plural light detectors can be selected as desired. In essence the reflector(s), etc., has to split the light into plural different paths, one for each detector.

In a preferred such arrangement, a reflector is provided with two main reflective surfaces, a first reflective surface which diverts incoming light from a light source toward a second reflective surface which diverts the light over a number of light detectors. In an alternative such arrangement, two reflectors can be provided which respectively function as the first and second reflective surfaces of the above reflector.

In a particularly preferred embodiment, the reflector or reflectors provide a degree of focusing of the light onto the light detectors (and/or into the light transmitting means). Preferably therefore, one or more of the reflectors are profiled in order to focus light onto the light detectors. For example, in the reflector described above which possesses two main reflective surfaces, the first reflective surface which intercepts incoming light from the light source may be generally planar to reflect light onto the second surface, and the second reflective surface can be profiled in a way to focus light onto each of a number of light detectors (or light transmitting means). In a preferred such arrangement, the reflector may include one or more generally concave reflective portions, each of which focuses light onto a particular light detector.

Focussing the light onto the light detectors can allow more efficient usage of the available light from the light source(s), and may therefore, for example, increase the number of light detectors that can be operated from a single light source.

The way and direction that the reflector(s) redirect the light can be selected as desired. However, in a particularly preferred embodiment, the reflector(s) is arranged to redirect the light such that it generally returns towards the light source (but laterally spaced therefrom) after it has left the reflector(s).

Indeed the Applicants believe this arrangement to be advantageous in its own right, and thus from a further aspect, the present invention provides an optical control comprising one or more light sources and one or more light directing means arranged to redirect the light from the light source or sources such that it returns towards the light source or sources but laterally spaced therefrom.

This arrangement enables in particular the light source(s) and light detector(s) or light transmitting means of the optical control to be placed generally side by side and facing generally in the same direction, since light from a light source can be directed by the reflector towards a position, e.g., a light detector, generally adjacent to the light source. This has the advantage that the light sources and light detectors or light transmitting means can be arranged on the same surface, e.g. side-by-side, and preferably in the same plane, thereby providing, for example, simplified construction (since, e.g., two facing light source and detector assemblies are not required). Thus in a particularly preferred embodiment, the light source or sources and light detector or detectors are arranged on the same surface, preferably in the same plane, and preferably facing in the same direction.

Indeed the Applicants believe this arrangement to be advantageous in its own right, and thus from a further aspect, the present invention provides an optical control comprising one or more light sources and one or more light detectors, wherein the light sources and light detectors are arranged on the same surface.

This aspect of the invention is not necessarily limited to the use of reflectors but extends to other mechanisms or arrangements, such as the use of prisms, optical fibres or other light transmitting means, that allow optical controls to be manufactured in which the light sources and light detectors are arranged generally on the same surface.

These aspects and embodiments of the invention in particular enable optical controls to be constructed that do not require the use of a number of subassemblies comprising electronic components mounted to small printed circuit boards which must then be arranged within a housing. Instead, the electronic components of the optical control can be disposed generally side by side and (preferably) mounted to the same element. Conveniently therefore, the light sources and light detectors or light transmitting means can be mounted to a single printed circuit board that both supports and electrically connects these components. The number of steps required in the construction of optical controls can therefore be reduced.

The Applicants have recognised in particular that with this arrangement, it would be possible to mount the light detectors or light transmitting means and light sources directly on a main printed circuit board, rather than requiring a separate optical control subassembly. Thus, in a particularly preferred embodiment, the light sources and light detectors are mounted on the same single printed circuit board, preferably a main printed circuit board of, e.g., a control panel.

Thus from a further aspect, the present invention provides a control panel comprising a control panel printed circuit board and one or more optical controls, the optical controls including light sources and light detectors, and light sources and light detectors of the controls being mounted directly on the control panel printed circuit board.

While the reflector(s) can be arranged as desired to allow the light detectors and light sources to be mounted facing in the same direction (and, e.g., side-by-side), in one preferred such form, the reflector is generally provided with two reflective surfaces. The first reflective surface is arranged at an angle to incoming light from a light source and reflects this light generally 90 degrees towards the second reflective surface. The second reflective surface is arranged at an angle to the incoming light from the first reflective surface and reflects this light generally a further 90 degrees. In this way, the light exiting the reflector can be generally directed in the opposite direction to light entering the reflector from a light source but is laterally spaced therefrom.

In the above arrangement, the two main reflective surfaces of the reflector are generally arranged at 90 degrees to each other and the reflector as a whole is oriented such that each reflective surface intersects incoming light at around 45 degrees. Alternatively, two reflectors may be provided, each respectively providing the function of the first and second reflective surfaces of the above described reflector.

As well as the light sources, light detectors or light transmitting means, and reflector(s), the optical controls of the present invention can and should include other components such as are known in conventional optical controls to allow them to function. Thus they will also include an appropriate control member that a user can use to operate the control. This could be a simple push button or toggle switch, or could be a rotary or sliding control or encoder, as is known in the art. The control member should be arranged to appropriately interrupt the light path from a light source to a light detector so that its position can be determined optically. In the case of a push button or toggle switch, the switch itself could move to block the

light path appropriately. Rotary or linear sliding controls should move appropriately encoded disks or plates that carry tracks having patterns of opaque and clear regions that selectively block different light paths in the encoder depending on their position to provide, e.g., a Gray code mapping of the control member's position, as is known in the art.

In a particularly preferred embodiment, the control further includes a cover element having apertures in it arranged over the light detectors (or paths to the light transmitting means, as appropriate), so as to provide an apertured entrance for light to each individual light detector (or light transmitting means). Arranging an aperture in front of each light detector, etc., helps to reduce stray light interference and ensure that only light intended for the respective detector, etc., will reach it. This helps to enhance the sensitivity of the arrangement, and can, for example, allow more detectors, etc., to be used in a smaller area. An increased density of light detectors, etc., may be particularly beneficial in optical controls where a high density of light detectors is required, for example, in optical encoders that have code generating members of a relatively small area or that require a relatively high resolution.

Preferably a cover element which includes a corresponding number of apertures so that the cover element can be arranged over a number of light detectors, etc., with an aperture located over each light detector, etc., is used. The apertured cover element is preferably formed from moulded plastic and preferably includes a snap-fit connection to allow the cover to be snap-fitted to a printed circuit board over light detectors that are attached to the circuit board. The invention also extends to the use of a number of such covers within an optical control.

It is believed that use of an apertured cover

element may be advantageous in its own right. Thus, from a further aspect, the present invention provides an optical control comprising:

one or more light sources;

a cover element formed with one or more apertures;

wherein the cover element is arranged such that light from a light source passes through an aperture in the cover element.

In this aspect and embodiments of the invention, the cover element should be arranged such that light on its path from a light source to a light detector must pass through an aperture in the cover element. Thus, where the control includes one or more light detectors, its cover element should be arranged over the light detectors with its apertures positioned such that light from a light source must pass through an aperture in the cover element to reach the light detectors.

The optical control preferably further includes a housing that can carry and cover one or more of the components of the control. The housing preferably mounts the reflector or reflectors and control member (e.g. switch) of the control, preferably in a push-fit (and preferably snap-fit) manner (as that simplifies the construction of the control). The housing could also carry the apertured cover element, if provided. The housing can preferably snap-fit to a printed circuit board, such that it can, for example, readily be mounted to a printed circuit board over the light sources and light detectors (which may be directly mounted to the printed circuit board first). The housing is preferably arranged such that it extends a uniform height above the printed circuit board, whatever the form of the optical control, as that facilitates, for example, interoperability of plural controls.

It will be appreciated by those skilled in the art that whilst it may be preferred that push-fit (preferably snap-fit) connections are provided to mount

the housing, apertured covers, etc., on, e.g., a printed circuit board, any other suitable form of connection such as glueing, soldering, heat-fixing and so on may also be used.

It will be appreciated from the above that the present invention provides an optical control that is particularly straightforward and convenient in its construction and use. Furthermore, arrangements of the present invention allow the electrical components of the optical control to be directly mounted on a single, e.g. main, e.g. control panel, printed circuit board (unlike in conventional optical controls and encoders where all the components are located in enclosed housings which must be electrically connected, say by wiring or soldering, to the main printed circuit board). In addition, where it is desired to provide a number of optical controls on a printed circuit board, it is possible to mount all of the electronic components on the same printed circuit board, thus significantly simplifying the construction.

The present invention therefore extends to methods of constructing optical controls. Thus, from a further aspect, the present invention provides a method of constructing an optical control or controls, comprising mounting the light sources and light detectors of one or more optical controls on a printed circuit board, and attaching a housing and/or other mechanical components of the control or controls to the printed circuit board.

The method can also include appropriately mounting the other components of the optical control, such as reflectors, apertured covers, control members, light transmitting means, etc., to the housing and/or circuit board, as desired. The light detectors could, as discussed above be mounted with each control, or a set of common light detectors could be used. The remainder of the printed circuit board could be used to mount, say, other optical controls, or other electronics

required by the electrical apparatus. As discussed above, where plural optical controls are mounted on a single printed circuit board, the housing of each control preferably extends to the same height above the circuit board.

The invention also extends to kits for constructing optical controls in accordance with the present invention.

Thus, from a further aspect, the present invention provides kit for an optical control, comprising:

a housing;

a movable control member mounted or mountable in the housing; and

one or more reflectors for location in the housing.

The reflectors in the kit should, as discussed above, be capable, in use, of reflecting light from one or more light sources onto one or more light detectors or into one or more light transmitting means.

In the case where the kit is for an optical encoder, the kit may further include a code generating member of any suitable form. The kit may also include one or more apertured covers, as described above, for location over the light detectors, etc., of the control. The kit preferably includes all the non-electronic parts required for construction of the optical control.

If desired, the kit may further include the electronic components, such as light sources and light detectors, which may then be pre-installed on a printed circuit board before the housing is fitted over them. The kit could also include appropriate light transmitting means (such as optical fibres) where these are to be used.

As discussed above, the present invention facilitates the use of plural optical controls on a single circuit board. In such an arrangement, the output of each control (whether electronic or optical (e.g. where a single set of detectors receives the light

output from plural optical controls)) is preferably received and processed in a common processing unit, e.g. microcontroller. In such an arrangement the system preferably polls each control in turn. To achieve this, the microcontroller could, for example, activate the light source, or light sources, of each control in turn and log the response from the control (i.e. store or read the code generated by the control which indicates the state or position of the control). The microcontroller can then repeatedly cycle through the controls, activating the light source(s) of each control in turn so that the position or state of all the controls can be ascertained.

The present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 illustrates a rotary optical encoder in accordance with a preferred embodiment of the present invention;

Figure 2 is a more detailed view of the device shown in Figure 1;

Figure 3 illustrates a linear optical encoder in accordance with another preferred embodiment of the present invention;

Figure 4 illustrates the relative movement of the code generating member with respect to the light sources and light detectors of the linear encoder shown in Figure 3;

Figure 5 illustrates a three-way switch in accordance with a further embodiment of the present invention;

Figure 6 illustrates a side view of the three-way switch shown in Figure 5;

Figure 7 illustrates a push button switch in accordance with a further embodiment of the present invention;

Figure 8 shows an exemplary electric circuit

configuration for coupling plural optical controls in accordance with an embodiment of the present invention; and

Figure 9 shows an exemplary optical circuit configuration for coupling plural optical controls in accordance with an embodiment of the present invention.

Figure 1 shows an optical control in the form of a rotary optical encoder 1. The encoder could have end stops or be continuous. The encoder 1 comprises a shaft 10 mounted for rotation within a housing 11. The rotatable shaft 10 may be connected to a turn knob structure (not shown) which can be grasped by a user to rotate the shaft 10. The housing 11 is attached to a printed circuit board (PCB) 2 by a snap-fit connection.

A (Gray) code generating disk 9 is located within the housing 11 and is attached to one end of the rotatable shaft 10 such that rotation of the shaft 10 causes rotation of the code generating disk 9.

The optical encoder 1 includes two light sources 3, 6, in the form of infra-red light emitting diodes (LEDs). Adjacent to each light source 3, 6 a series of three light detectors 4, 7 are arranged in a line extending radially from the axis of rotation of the code generating disk 9. The light detectors 4, 7 comprise, for example, phototransistors. The light sources 3, 6 are located generally in line with their respective series of three light detectors, and in this case are located radially between the light detectors and the axis of rotation of the code generating disc 9.

The control further includes an apertured covers 5, 8 arranged over the light detecting members 4, 7. The covers are formed from moulded plastic and attached to the printed circuit board (PCB) 2 by a snap-fit connection. Each cover is formed with three apertures, one for each light detector, that allow light to pass through the cover 5 for detection.

As can be seen, the light sources 3, 6 and the

light detectors 4, 7 are mounted directly to the printed circuit board and lie on the same side of the code generating disk 9 and face in the same direction.

On the opposite side of the code generating disk 9 is provided a reflector 12 which redirects the light from the light sources 3, 6 to the detectors 4, 7.

The operation of the reflector is illustrated in figure 2. Figure 2 shows the arrangement for the light source 3 and light detectors 4, but as will be appreciated by those skilled in the art, the corresponding arrangement and processes take place with the light source 6 and detectors 7. The reflector 12 comprises a first reflective surface 14 which reflects the incident light from the light source 3 into a number of concave secondary reflective surfaces 15 each of which reflects light through the apertured cover 5 towards a particular light detector 4. The secondary reflective surfaces are concave to help focus the incident light onto a particular light detector.

In use, the light from the light source 3 passes through a transparent portion 13 of the code generating disk 9 and is appropriately reflected by the reflector 12 to provide three light beams, one for each light detector 4. These light beams return to the detectors 4 through the code generating disk 9.

As is known in the art, the disk 9 includes opaque and transparent regions 16 that will selectively block the light path to the detectors 4 (and 7). In this way the position of the disk 9 controls output of the detectors 4, 7, such that the light detectors' output is indicative of the disk's position (and hence of the position of the rotary control). Typically the pattern of apertures in the disk 9 will be such that the optical output provides a Gray code mapping of the disk's position, as is known in the art. The Gray code can, for example, be provided to and interpreted by a microprocessor or microcontroller, provided to and

interpreted by a programmable logic device to output a signal recognisable by an analogue circuit (such as a stepped voltage or with another device as a change in resistance), etc., as is known in the art.

The arrangement shown in Figures 1 and 2 can encode 64 positions. The number of positions can be varied by using more or less light detectors. The switch could have end stops (e.g. to limit its rotation to 270°) and if being used as a selector switch could be constructed with intermediate stops to correspond to the Gray code positions.

Figure 3 shows a cross-section of an optical linear slider control. The slider control includes similar components to the above described rotary optical control. The slider control comprises a slider 25 mounted in and extending from a housing 24. The housing 24 is attached to a printed circuit board by means of a snap-fit connection. The slider 25 is linearly translatable relative to the housing 24. A code generating member 23 is attached to the slider 25 such that linear movement of the slider 25 causes corresponding movement of the code generating member 23 within the housing 24.

As can be seen in figure 3, the slider control is generally symmetrical when viewed in cross-section. Each side of the control is provided with a light source 20 and three light detectors 21. The light source 20 comprises an infra-red light emitting diode LED and the light detectors 21 comprise phototransistors. The light source 20 and the three light detectors 21 are arranged linearly. For a longer control plural sets of linearly spaced light sources and light detectors may be provided along the length of the control.

The code generating member 23 that is moved by the control and selectively blocks the light paths to the detectors comprises a generally rectangular element formed from a photographic material that is formed with

transparent regions and opaque regions.

Figure 4 shows an example of a linear control having four light sources and corresponding light detector positions (although only eleven light detectors are used) 18, 19, 26, 27. The code generating member is moved linearly over these positions and includes a number of linear tracks of opaque and transparent regions 28, 29, 30, 31, 32 which, as can be seen, selectively block or transmit light to a given photodetector depending on the linear position of the code generating member 23. Figure 4a shows the code generating member 23 at one end of its travel, Figure 4b at its central position, and Figure 4c at the other end of its travel. As can be seen from Figure 4, each step of the code generating member 23 provides its own unique light detector "on" pattern. This allows the optical output from the light detectors to be used to determine the position of the code generating member 23 and thereby of the linear control. A longer control (and with more positions) could be provided using additional rows of light sources and photodetectors.

The dimensions of the linear control can be selected as desired. For example, for a 45 mm travel slider, there could be one row of five and one row of six photodetectors light detectors (as shown) giving 64 positions each of step size 0.7 mm.

Figures 5 and 6 illustrate an optical three-position lever switch that operates in accordance with the present invention. The switch includes a user operable control member 37 which can be moved to move a member 36 between three positions (left, centre and right). The switch includes two light sources 34 and two light detectors 35. The light sources 34 are arranged so that the member 36 in its "left" position blocks the light output from one light source 34 from reaching one light detector 35 and when in its "right" position blocks the light output from the other light

source 34 from reaching the other light detector 35. When the member 36 is in its "centre" position it does not block light from either light source 34 from reaching its respective light detector 35. Thus a unique code can be generated for the three positions of the lever switch.

The switch shown in Figures 5 and 6 has a toggle action, but a slide action could also be used. For a two-position lever switch, only one light source and light detector would be required.

Figure 7 illustrates a push button switch in accordance with the present invention. The switch includes a push button 44, a light source 32, reflectors 45, 46 and a light detector 43. The push button 44 can be selectively operated by a user to block the light path from the light source 42 to the light detector 43, but is resiliently biassed towards its outward position. This type of switch is an example of a "latching" or "momentary" switch as the push button 44 is biassed towards a particular position (either the on or off position) by means such as a spring so that after the push button 44 has been pressed it returns to its original position (usually the off position).

As has been discussed above, the present invention in particular facilitates the use of plural optical controls on a single circuit board or in a single electronic element. In such an arrangement it may be desirable that while each optical control may produce its own output (whether electrical or optical) the outputs of the various optical controls are processed and handled by a common, single processing unit, such as a microcontroller. Figures 8 and 9 illustrate appropriate arrangements to achieve this.

Figure 8 shows five optical controls 47 which provide via their respective light detectors electrical outputs indicative of their state via wires 49 to a common microcontroller 48. Figure 8 shows five

different optical devices, each of which possesses a different number of light sources and light detectors, including an optical linear encoder, an optical rotary encoder, an optical selector switch and an optical toggle switch, an optical push-button switch. However, as will be appreciated by those skilled in the art, this selection of optical controls is exemplary only and, furthermore, the connections shown between the components are illustrated schematically. These electrical connections may comprise wires, circuits on printed circuit boards, and so on, as is known in the art.

As can be seen, each optical device 47 includes an electrical input for each light source (infra-red LED) present within the control. Each optical device also includes an electrical output from each light detector (phototransistor) present within the control. The electrical outputs from the light detectors with the same weight (from LSB to MSB) are connected in parallel to the microcontroller 48. The microcontroller also provides the electrical input required by each light source. In order to read the state of each optical control, the microcontroller interrogates each control in turn by activating the light sources within that control. An electrical response is then received from that controller which indicates the current state of that control. The microcontroller 48 then switches its attention to the next optical control and so on.

Figure 9 shows an alternative form of interconnection between a number of optical controls 50 and a microcontroller 51. Unlike the arrangement shown in figure 8, the components shown in figure 9 are not interconnected by electrical connections but are instead connected optically via optical fibres 52. In this arrangement, the controls 50 are not individually provided with light detectors which provide a electrical signal to the microcontroller when exposed to light from

a light source. Instead, the light from the light sources within each optical control is transmitted as light via optical fibres 52 to a single, common, set of light detectors 53 arranged at the microcontroller 51. In this way an optical connection is provided between the optical controls and microcontroller 51. This arrangement can save, for example, on the number of light detectors required.

Whilst the present invention has been described with reference to preferred embodiments, it will be apparent to those skilled in the art that various changes can be made in form and detail without departing from scope of the invention.

In particular, the invention has been described, in part, in relation to optical encoders of a type know as "absolute" encoders which allow the absolute position of a mechanical element to be identified. The invention is however equally applicable to relative or "incremental" optical encoders in which the tracks of a code generating disk are divided into a regular series of transparent and opaque regions such that the movement of a control member from one position to another produces a series of pulses which can be counted to provide an indication of how far the control member has moved.

The present invention can be used for optical controls generally, such as linear controls, e.g. encoders, of various lengths, rotary controls, e.g. controllers with or without stops, selector switches, lever switches and push button switches, etc.

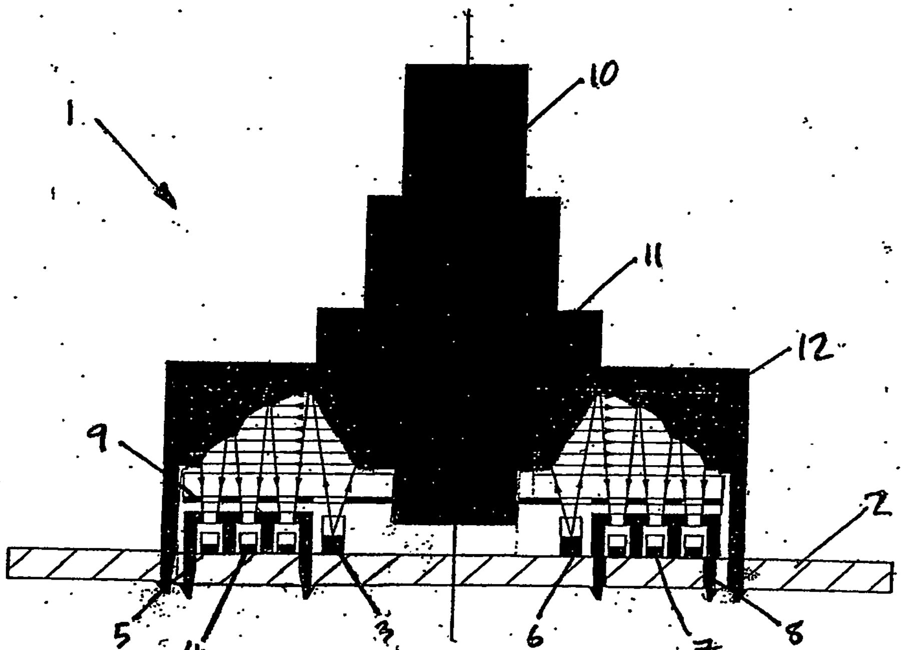

FIG. 1

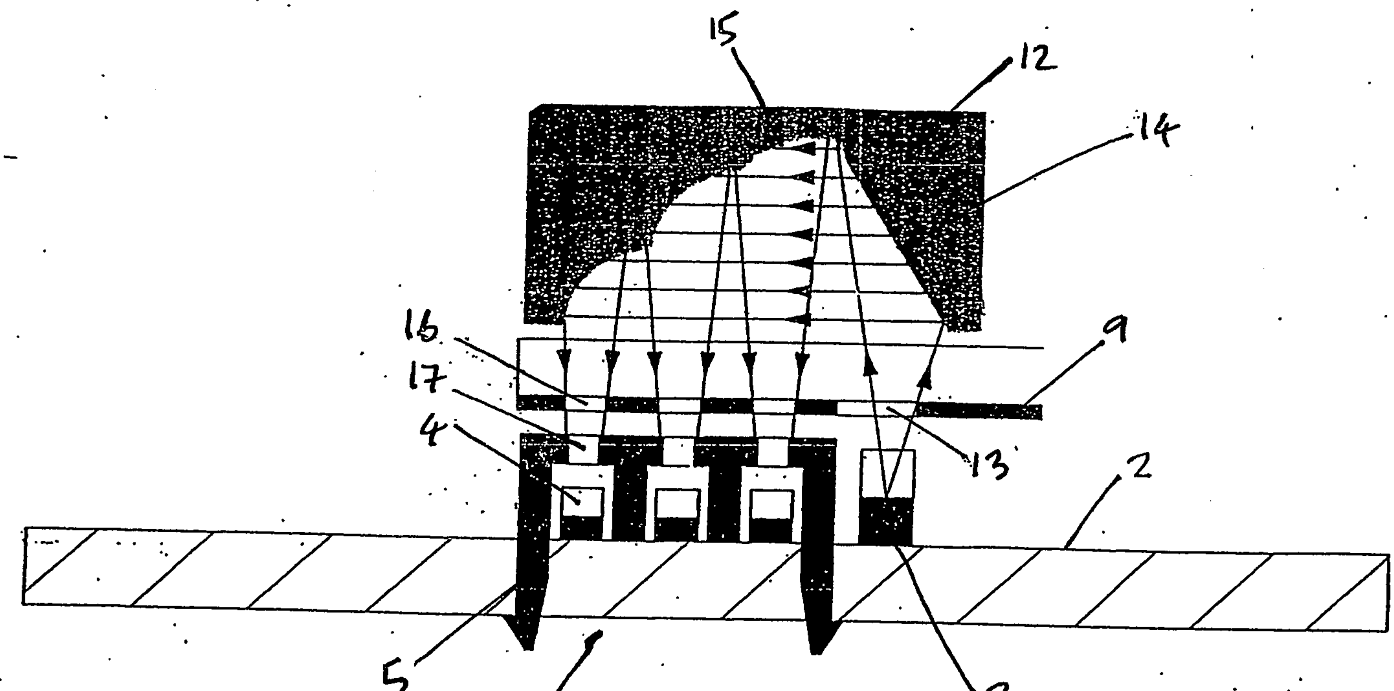

FIG. 2

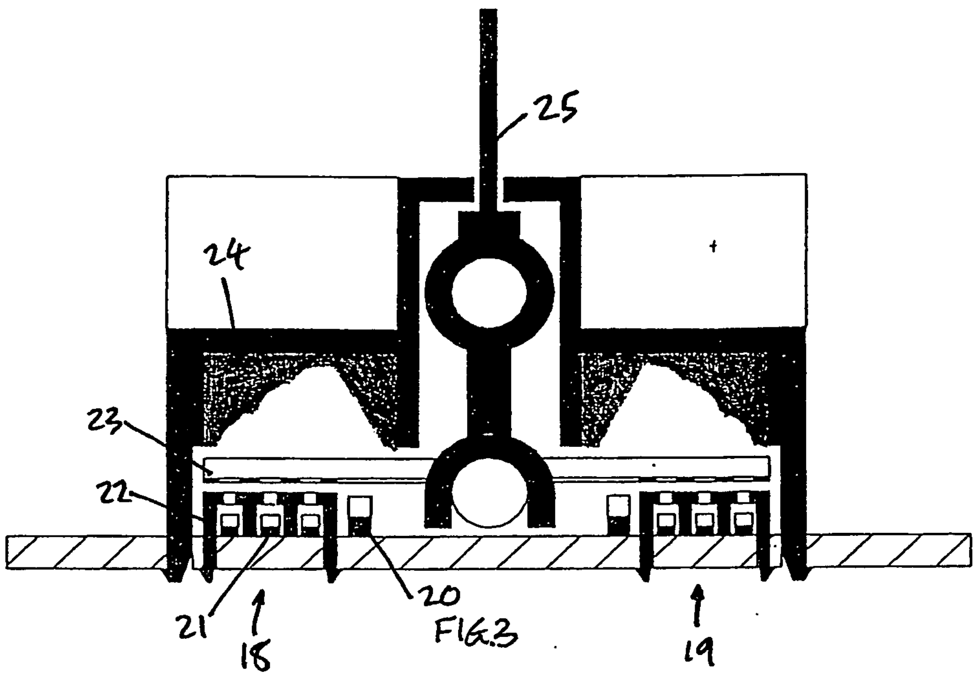
25
24
23
22
21
18
20
19

FIG.3

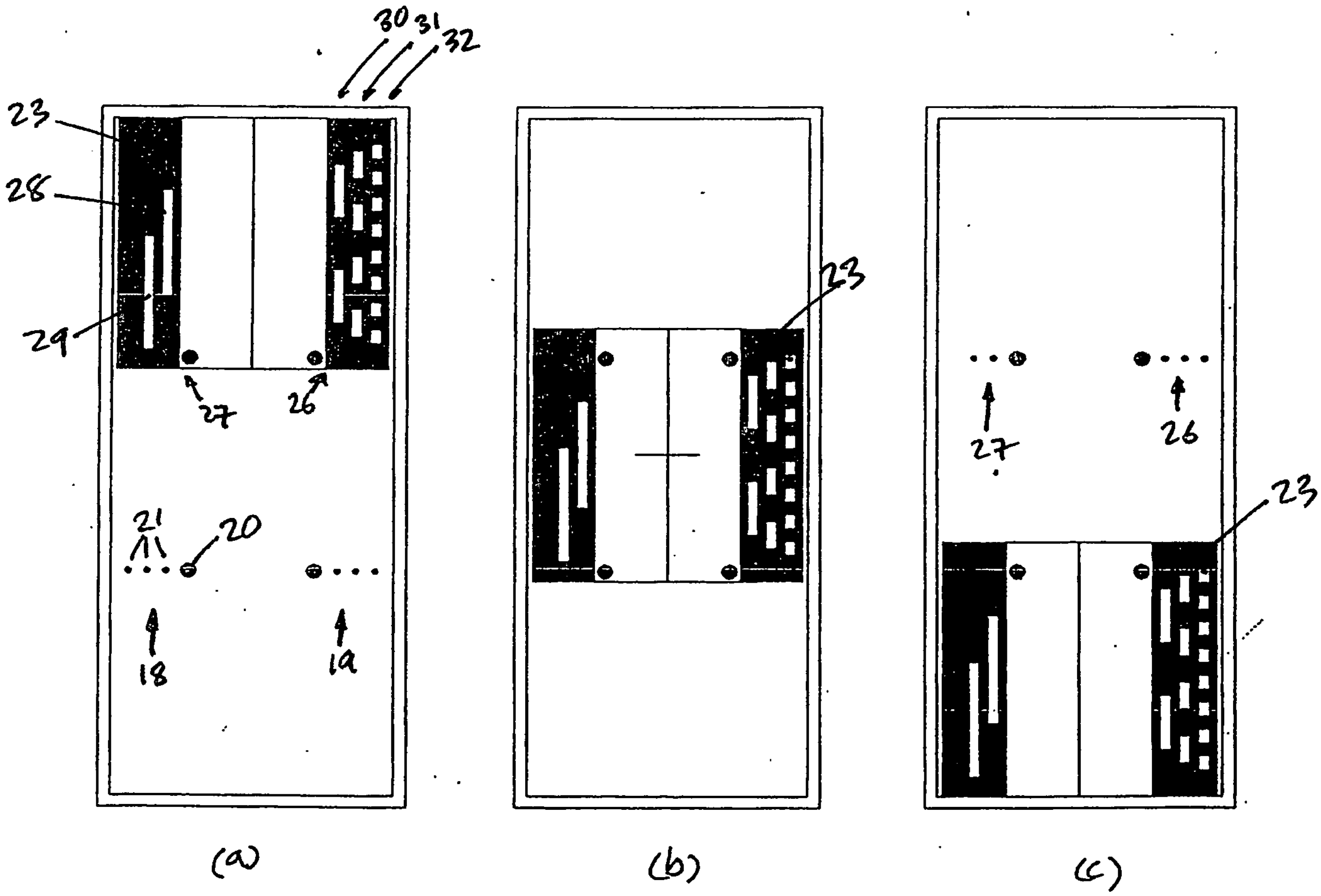
30
31
32
23
28
29
27
26
21
20
18
19
23
27
26
23
(a)
(b)
(c)

FIG.4

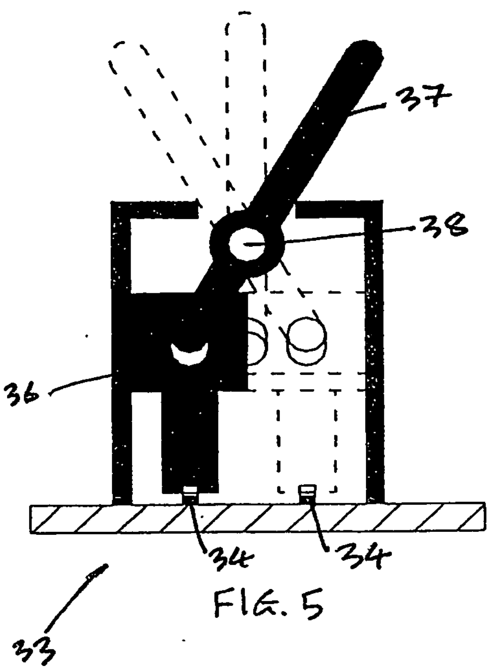

FIG. 5

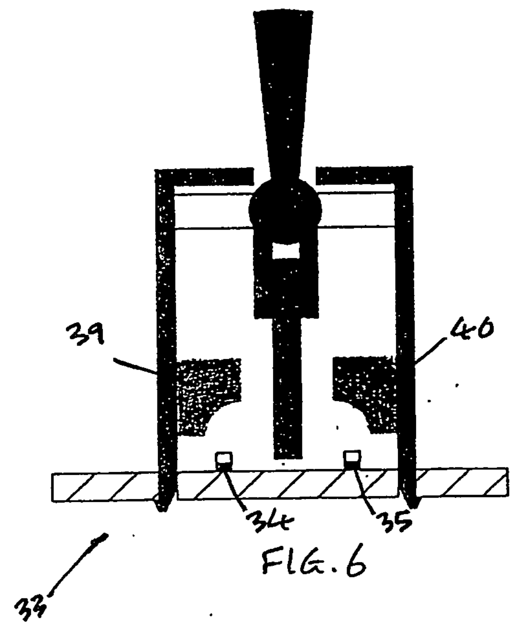

FIG. 6

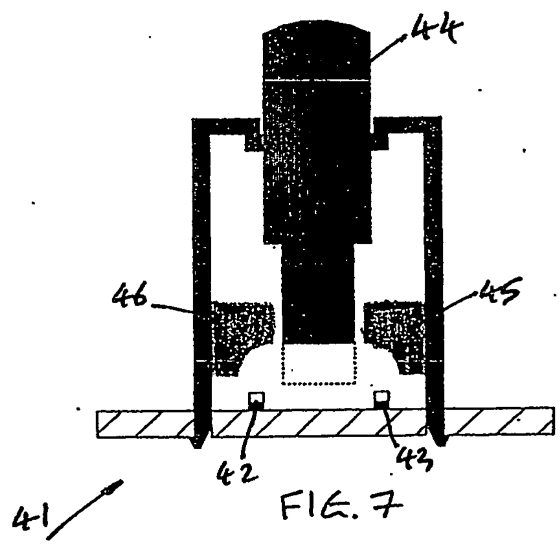

FIG. 7

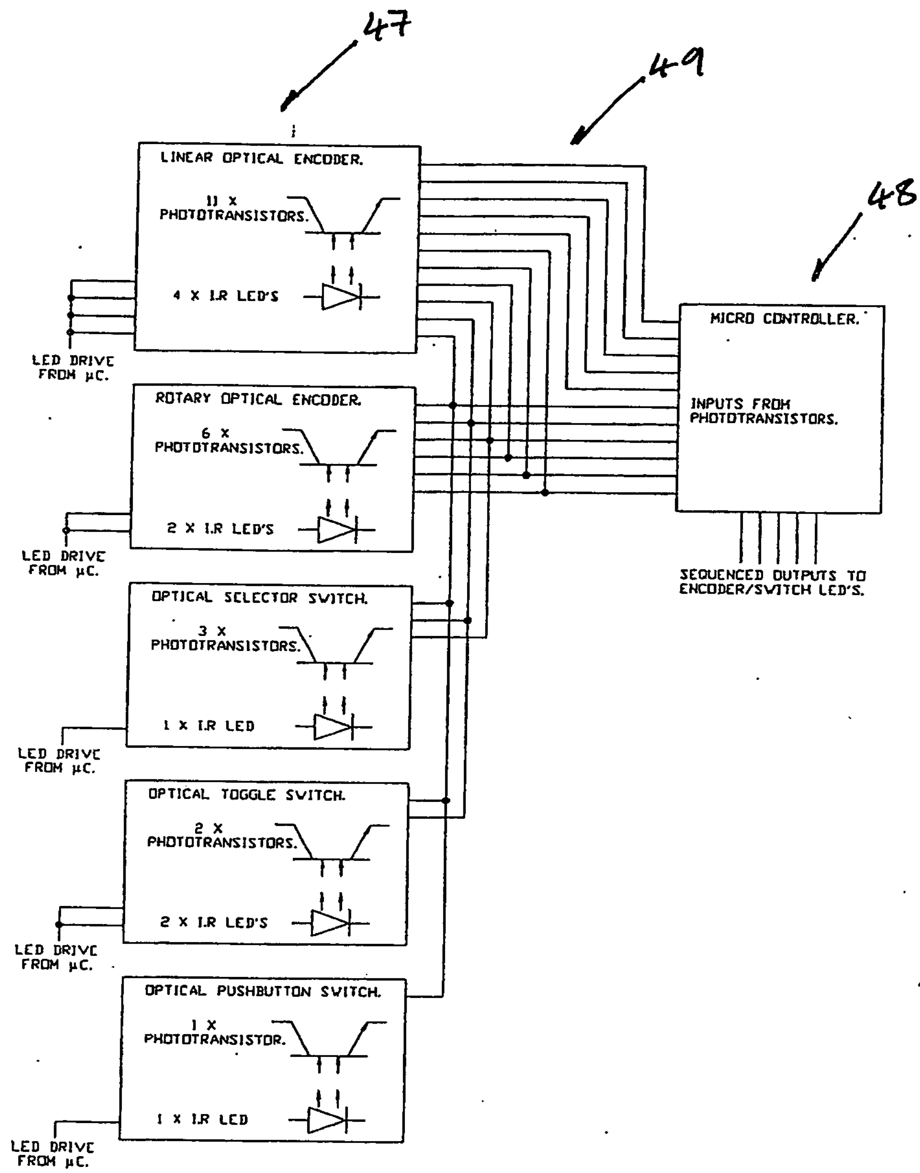
47
49
48
LINEAR OPTICAL ENCODER.
11 X PHOTOTRANSISTORS.
4 X I.R LED'S
LED DRIVE FROM µC.
ROTARY OPTICAL ENCODER.
6 X PHOTOTRANSISTORS.
2 X I.R LED'S
LED DRIVE FROM µC.
OPTICAL SELECTOR SWITCH.
3 X PHOTOTRANSISTORS.
1 X I.R LED
LED DRIVE FROM µC.
OPTICAL TOGGLE SWITCH.
2 X PHOTOTRANSISTORS.
2 X I.R LED'S
LED DRIVE FROM µC.
OPTICAL PUSHBUTTON SWITCH.
1 X PHOTOTRANSISTOR.
1 X I.R LED
LED DRIVE FROM µC.
MICRO CONTROLLER.
INPUTS FROM PHOTOTRANSISTORS.
SEQUENCED OUTPUTS TO ENCODER/SWITCH LED'S.

FIG. 8

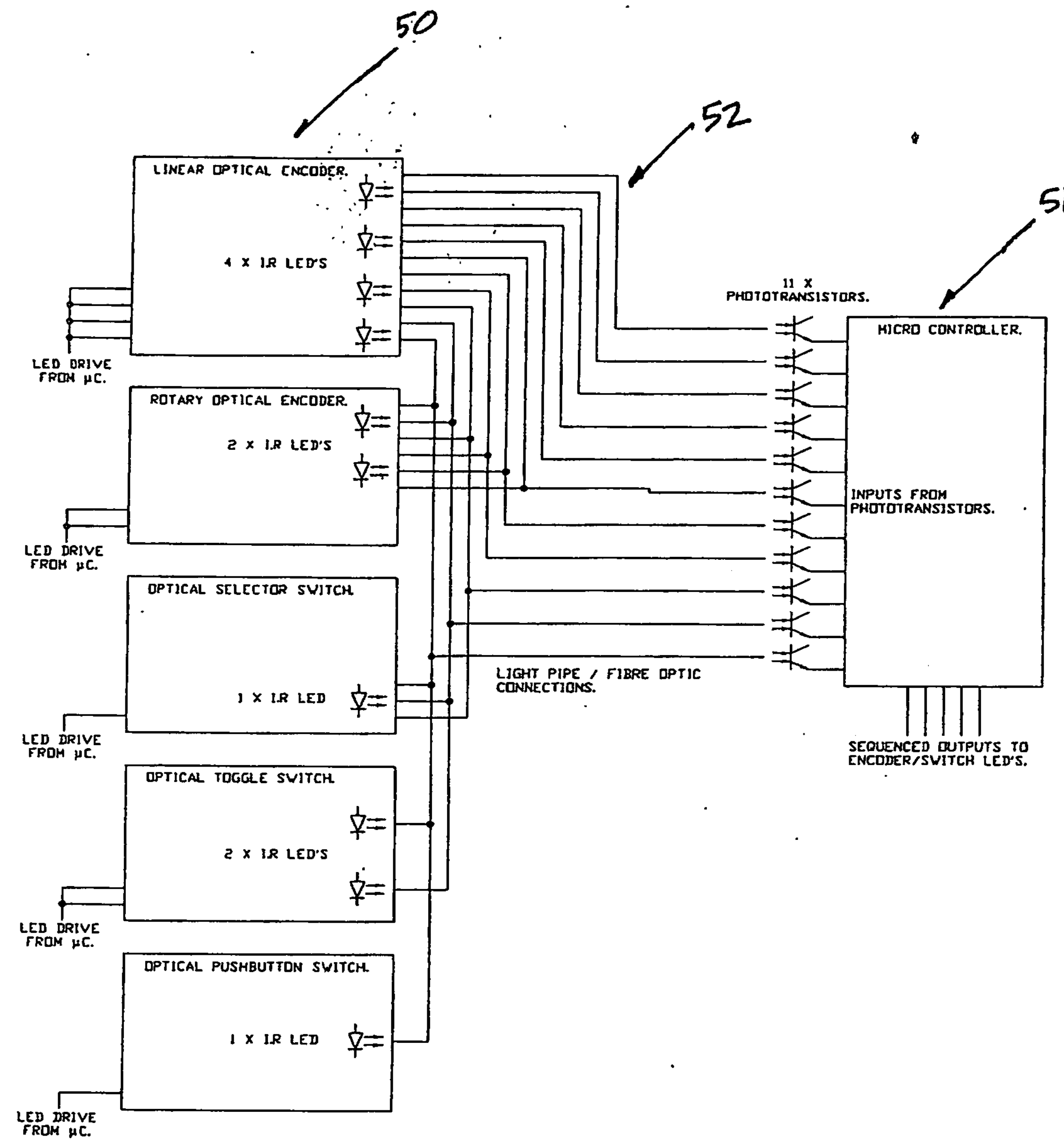
50
52
51
LINEAR OPTICAL ENCODER.
4 X I.R LED'S
LED DRIVE FROM µC.
ROTARY OPTICAL ENCODER.
2 X I.R LED'S
LED DRIVE FROM µC.
OPTICAL SELECTOR SWITCH.
1 X I.R LED
LED DRIVE FROM µC.
OPTICAL TOGGLE SWITCH.
2 X I.R LED'S
LED DRIVE FROM µC.
OPTICAL PUSHBUTTON SWITCH.
1 X I.R LED
LED DRIVE FROM µC.
11 X PHOTOTRANSISTORS.
MICRO CONTROLLER.
INPUTS FROM PHOTOTRANSISTORS.
LIGHT PIPE / FIBRE OPTIC CONNECTIONS.
SEQUENCED OUTPUTS TO ENCODER/SWITCH LED'S.

FIG.9